Claims

1. A device for use in a gaseous environment, comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end adapted to be controllable by an operator, the instrument comprising

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen including at least one nozzle providing a jet opening; and

an evacuation lumen including a jet-receiving opening locatable opposite the jet opening, at a predetermined distance therefrom, to receive a liquid jet when the instrument is in operation; wherein

the nozzle is shaped to form a liquid jet, as a liquid at high pressure flows therethrough, the liquid jet comprising a diverging region of liquid droplets moving through the gaseous environment, with the diverging region having an apex located at the jet opening, such that essentially all of the moving liquid droplets in the diverging region are directed into the jet-receiving opening when the instrument is in operation.

2. A device as in claim 1, wherein the evacuation lumen is shaped and positionable to enable evacuation of essentially all of the liquid comprising the liquid jet from the jet-receiving opening to a proximal end of the evacuation lumen without the need for an external source of suction.

3. A device as in claim 1, wherein the pressure lumen includes at least two nozzles each providing a jet opening.

4. A device as in claim 1, wherein the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that back flow of a spray or a liquid mist from the jet-receiving opening into the gaseous environment is essentially eliminated when the instrument is in operation.

5. A device as in claim 1, wherein the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that a cross-sectional shape and area of the liquid jet at a given location within the evacuation lumen, the given location being at least one of the jet-receiving opening and a location proximal to the jet-receiving opening, is essentially the same as an internal cross-sectional shape and area of the evacuation lumen at the given location, when the instrument is in operation.

6. A device as in claim 1, wherein the instrument includes a sheath surrounding at least a portion of the pressure lumen and the evacuation lumen.

7. A device as in claim 6, wherein the sheath is essentially straight with a longitudinal axis that is essentially parallel to a longitudinal axis of the proximal end of the surgical instrument.

8. A device as in claim 6, wherein the sheath has a proximal and a distal region and is at least one of curved and angled in the distal region of the sheath.

9. A device as in claim 1, wherein an axis defining a direction of at least a central region of the liquid jet and a longitudinal axis of the proximal end of the surgical instrument are essentially parallel when the instrument is in operation.

10. A device as in claim 1, wherein an axis defining a direction of at least a central region of the liquid jet and a longitudinal axis of the proximal end of the surgical instrument are non-parallel to each other when the instrument is in operation.

11. A device as in claim 1, wherein the diverging region of liquid droplets has a truncated cone shape.

12. A device as in claim 1, wherein the nozzle has a region of minimum cross-sectional diameter having a predetermined length, the ratio of the predetermined length to the minimum cross-sectional diameter being not greater than about four.

13. A device as in claim 12, wherein the ratio of the predetermined length to the minimum cross-sectional diameter is not greater than about two.

14. A device as in claim 1, further comprising a body that includes a grasping region shaped and positionable to be held by a hand of the operator.

15. A device as in claim 1, wherein the surgical instrument is constructed and arranged to be entirely disposable after a single use.

16. A device for use in a gaseous environment, comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end adapted to be controllable by an operator, the instrument comprising

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen including at least one nozzle providing a jet opening; and

an evacuation lumen having a proximal end and a distal end, the distal end including a jet-receiving opening locatable opposite the jet opening at a predetermined distance therefrom to receive the liquid jet when the instrument is in operation; wherein

the evacuation lumen is shaped and positionable to enable evacuation of essentially all of the liquid comprising the liquid jet from the jet-receiving opening to the proximal end of the evacuation lumen without the need of an external source of suction.

17. A device as in claim 16, wherein the surgical instrument is constructed and arranged to be entirely disposable after a single use.

18. A device as in claim 16, wherein the pressure lumen includes at least two nozzles each providing a jet opening.

19. A device as in claim 16, wherein the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that back flow of a spray or a liquid mist from the

jet-receiving opening into the gaseous environment is essentially eliminated when the instrument is in operation.

20. A device as in claim 16, wherein the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that a cross-sectional shape and area of the liquid jet at a given location within the evacuation lumen, the given location being at least one of the jet-receiving opening and a location proximal to the jet-receiving opening, is essentially the same as an internal cross-sectional shape and area of the evacuation lumen at the given location, when the instrument is in operation.

21. A device as in claim 16, further comprising a body that includes a grasping region shaped and positionable to be held by a hand of the operator.

22. A method comprising:

inserting a surgical liquid-jet instrument into a joint capsule of a patient;

creating a liquid jet with the surgical liquid-jet instrument;

directing the liquid jet towards a jet-receiving opening in an evacuation lumen of the surgical liquid-jet instrument; and

cutting or ablating a selected tissue within the joint capsule with the liquid jet.

23. A method as in claim 22, wherein the joint capsule comprises a human knee and the selected tissue comprises posterior meniscus tissue.

24. A method as in claim 22, wherein the joint capsule comprises a human shoulder.

25. A method as in claim 22, wherein during the inserting step, the surgical liquid-jet instrument is in an undeployed configuration and after the inserting step and before the creating step, the surgical liquid-jet instrument is deployed to create a separation distance between a jet opening from which the liquid jet emerges and the jet-receiving opening, the separation distance defining a path length for the liquid jet.

26. A method as in claim 22, wherein the cutting or ablating step comprises positioning a section of tissue in contact with an entrainment zone of moving liquid surrounding the liquid jet.

27. A method as in claim 22, wherein the cutting or ablating step comprises positioning a jet opening, from which the liquid jet emerges, in close proximity to a solid surface within the joint capsule, directing the liquid jet essentially tangential to the solid surface, and removing the selected tissue from the surface.

28. A method as in claim 22, wherein the cutting or ablating step comprises positioning a jet opening, from which the liquid jet emerges, adjacent to a solid surface within the joint capsule, directing the liquid jet essentially tangential to the solid surface, and removing the selected tissue from the surface.

29. A method as in claim 22, further comprising removing liquid comprising the liquid jet and the selected tissue from the joint capsule without applying a source of external suction in fluid communication with the evacuation lumen.

30. A method comprising:

positioning a surgical liquid-jet instrument in close proximity to a surface of a body of a patient;

creating a liquid jet in a surrounding gaseous environment with the surgical liquid-jet instrument;

directing the liquid jet essentially tangential to the surface and towards a jet-receiving opening in an evacuation lumen;

debriding a material from the surface with the liquid jet; and

evacuating a liquid comprising the liquid jet and the debrided material from the jet-receiving opening to a proximal end of the evacuation lumen without the need for an external source of suction.

31. A method as in claim 30, wherein the surface of a body of a patient comprises an external body surface.

32. A method as in claim 31, wherein the external body surface at least partially comprises human skin.

33. A method as in claim 30, wherein at least a portion of the material debrided during the debriding step comprises at least one of living tissue and dead tissue.

34. A method as in claim 30, wherein at least a portion of the material debrided during the debriding step comprises foreign matter embedded in the surface prior to the debriding step.

35. A device comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end including a body, the body having a grasping region shaped and positionable to be held by a hand of an operator, the instrument comprising:

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen including at least one nozzle providing a jet opening; and

an evacuation lumen including a jet-receiving opening locatable opposite the jet opening at a predetermined distance therefrom to receive a liquid jet when the instrument is in operation; wherein

at least one nozzle comprises a hole in a side wall of a lumen.

36. A device as in claim 35, wherein the evacuation lumen includes a region within and adjacent to the jet-receiving opening, the evacuation lumen being shaped so that a liquid within the region is able to macerate at least a portion of a tissue entrained in the liquid into a plurality of particles when the instrument is in operation.

37. A device as in claim 35, wherein the nozzle is shaped to form a liquid jet as a liquid at high pressure flows therethrough and the liquid jet and the evacuation lumen are shaped and positionable such that a substantial fraction of a tissue entrained by the liquid jet is reduced to a plurality of microscopic particles when the instrument is in operation.

38. A device as in claim 35, wherein at least a portion of the pressure lumen and at least a portion of the evacuation lumen are movable relative to each other to enable adjustment of a separation distance between the jet opening and the jet-receiving opening.

39. A device as in claim 35, wherein the evacuation lumen has an internal cross-sectional area which increases continuously from a minimum value at the jet-receiving opening to a maximum value at a predetermined position proximal to the jet-receiving opening, which maximum value is essentially constant at positions proximal to the predetermined position.

40. A device as in claim 35, wherein the evacuation lumen is shaped and positionable to enable evacuation of essentially all of the liquid comprising the liquid jet from the jet-receiving opening to a proximal end of the evacuation lumen without the need for an external source of suction.

41. A device as in claim 35, wherein the surgical instrument is constructed and arranged to be entirely disposable after a single use.

42. A device as in claim 35, wherein the surgical instrument is constructed and arranged to be operated in a gaseous environment, where at least one of the jet opening and the jet-receiving opening are essentially entirely surrounded be a gas when the instrument is in operation.

43. A method comprising:

necking down an end of a tube providing a lumen to form a jet nozzle region in the tube having a reduced cross-sectional dimension; and

offsetting the jet nozzle region from being essentially co-linear with an axial centerline of the tube outside the jet nozzle region to a position where an axial centerline of the jet nozzle region is displaced from the axial centerline of the tube outside the jet nozzle region by a distance of about d=R-r, where R is the internal radius of the tube outside the jet nozzle region and r is the internal radius of the jet nozzle region.

44. A method as in claim 43, wherein the method further comprises the step of bending the offset jet nozzle region so that the axial centerline of the jet nozzle region is non-parallel to the axial centerline of the tube outside the jet nozzle region.

45. A method as in claim 44, wherein the axial centerline of the jet nozzle region forms an angle with the axial centerline of the tube outside the jet nozzle region of about 90 degrees.

46. A method as in claim 44, wherein essentially no portion of the jet nozzle region projects radially beyond a perimeter defined by an outer surface of the tube outside the jet nozzle region.

47. A device for use in an gaseous environment, comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end adapted to be controllable by an operator, the instrument comprising:

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen having a distal end including at least two nozzles, each providing a jet opening, each nozzle shaped to form a liquid jet as a liquid at high pressure flows therethrough; and

an evacuation lumen having a distal end including a jet-receiving opening locatable opposite at least one of the jet openings, at a predetermined distance therefrom, the distance defining a gas-filled gap between the jet opening and the jet-receiving opening, the jet-receiving opening shaped and positionable to receive at least one liquid jet when the instrument is in operation.

48. A device as in claim 47, wherein the jet-receiving opening is shaped and positionable to receive each liquid jet when the instrument is in operation.

49. A device as in claim 47, wherein the evacuation lumen is shaped and positionable to enable evacuation of essentially all of the liquid comprising at least one liquid jet from the

jet-receiving opening to a proximal end of the evacuation lumen without the need for an external source of suction.

50. A device as in claim 48, wherein the evacuation lumen is shaped and positionable to enable evacuation of essentially all of the liquid comprising each liquid jet from the jet-receiving opening to a proximal end of the evacuation lumen without the need for an external source of suction.

51. A device for use in a gaseous environment, comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end adapted to be controllable by an operator, the instrument comprising:

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen including at least one nozzle providing a jet opening; and

an evacuation lumen including a jet-receiving opening locatable opposite the jet opening at a predetermined distance therefrom to receive a liquid jet when the instrument is in operation; wherein

the nozzle is shaped to form a liquid jet as a liquid at high pressure flows therethrough, the liquid jet being directed across an gas-filled gap and into the jet-receiving opening when the instrument is in operation, and

the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that back-flow of a liquid mist or spray from the jet-receiving opening into the gas-filled gap is essentially eliminated when the instrument is in operation.

52. A device as in claim 51, wherein the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that a cross-sectional shape and area of the liquid jet at a given location within the evacuation lumen, the given location being at least one of the jet-receiving opening and a location proximal to the jet-receiving opening, is essentially the same as an internal cross-sectional shape and area of the evacuation lumen at the given location, when the instrument is in operation.

53. A device for use in a gaseous environment, comprising:

a surgical instrument having a distal end adapted to perform a surgical procedure on a patient and a proximal end adapted to be controllable by an operator, the instrument comprising:

a pressure lumen having sufficient burst strength to conduct a high pressure liquid towards the distal end of the instrument, the pressure lumen including at least one nozzle providing a jet opening; and

an evacuation lumen including a jet-receiving opening locatable opposite the jet opening at a predetermined distance therefrom to receive a liquid jet when the instrument is in operation; wherein

the nozzle is shaped to form a liquid jet as a liquid at high pressure liquid flows therethrough, the liquid jet being directed across a gas-filled gap and into the jet-receiving opening when the instrument is in operation, and

the nozzle and the jet-receiving opening are shaped and positionable relative to each other so that a cross-sectional shape and area of the liquid jet at a given location within the evacuation lumen, the given location being at least one of the jet-receiving opening and a location proximal to the jet-receiving opening, is essentially the same as an internal cross-sectional shape and area of the evacuation lumen at the given location, when the instrument is in operation.

54. A device as in claim 53, wherein the given location is the jet-receiving opening.

55. A device as in claim 53, wherein the given location is the no greater than about 5 mm proximal to the jet-receiving opening.